NASA TECH BRIEF

NASA Pasadena Office

Low-Noise Microwave Polarimeter

The problem:

To equip a microwave antenna with a system which can track and measure the polarization of weak microwave signals.

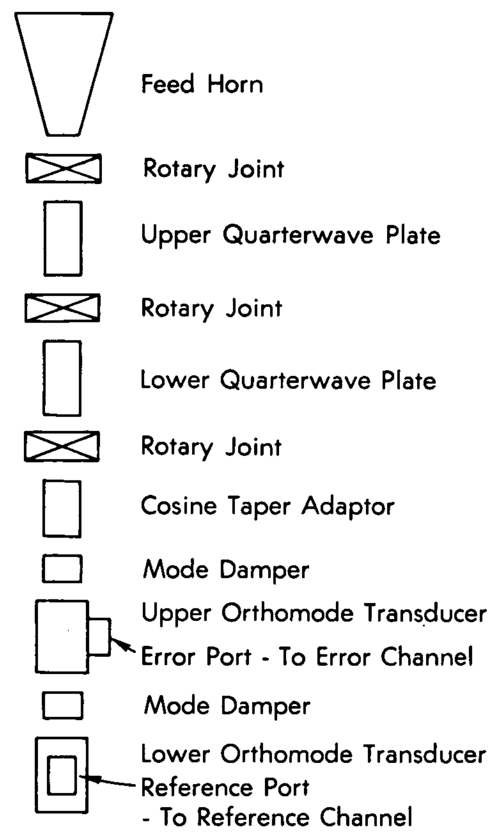
The solution:

A combination of two quarterwave-plate polarizers inserted between rotary waveguide joints transforms received signals from arbitrary linear to circular polarizations and then from circular to fixed linear polarizations; the fixed linear polarizations are applied to amplifiers and filters in the usual fashion.

How it's done:

The polarizer is constructed integral with the front end of the receiver in the feed-cone system of a Cassegrainian antenna. The component parts of the polarizer system are indicated in the block diagram. The system can receive or transmit signals which have right circular polarization, left circular polarization, or rotatable linear polarization. The feed cone employs a dual mode horn followed by two quarterwave plates mounted between three rotatable joints (remotely controlled). The angular displacement of the quarterwave plates is sensed by synchros through gears mounted on the quarterwave plates and is indictated on a monitoring panel in the control room.

When the upper quarterwave plate is correctly aligned with the incident signal, it converts the linearly-polarized signal to one sense of circular polarization. The lower quarterwave plate converts the circular polarization back to the linear mode and transmits the signal to one of the two orthogonal output ports of the orthomode assembly elements. Mode dampers precede each transducer in order to suppress the higher-order modes that are generated by the presence of the asymmetric rectangular-to-cylindrical waveguide junctions in each transducer. The cosine taper adaptor is necessary for matching the electrical



properties of the larger quarterwave plate assembly to the smaller diameter orthogonal-mode transducers.

When the upper quarterwave plate is incorrectly aligned, both senses of circular polarization (left and

(continued overleaf)

right) are generated, and some of the signal appears at the second transducer port for injection into an error channel receiver. The alignment of the lower quarterwave plate is at 45° with respect to the position of the orthomode ports. The lower quarterwave plate is capable of a neutral position, as well as ±45° positions with respect to the two orthogonal outputs. The lower quarterwave plate position is therefore a basic adjustment which lends versatility to the polarizer, i.e., the ability to adapt to different space mission polarization measurement requirements, such as switchable and/or circular polarizations. For circularly-polarized reception or transmission, the lower quarterwave plate is set to the neutral position and only the upper unit is used.

The polarizer can be adjusted manually for high-accuracy polarimetric measurements; additionally, it has been used in an automatic polarization tracking system in which the lower quarterwave plate was used as the reference orientation and the upper quarterwave plate was used as the rebalance element of the servo loop. When the polarizer is operated in automatic servo mode, both the reference channel and error channel ports transmit signals through a rectangular waveguide to maser amplifiers which are operated in their own closed-cycle cryostats at 4.2°K. In this mode, the reference channel maser is connected to the space communications receiver in its normal configuration, and the error-channel maser is connected to a receiver which develops an error voltage proportional to the difference in phase between a sample of the reference-channel signal and the error-channel signal. The error voltage is used to adjust the position of the upper quarterwave plate, and the plate displacement is rapid enough to track the angular change in polarization of an incident signal from space under the influence of Faraday rotation, or spacecraft tumbling at a low rate.

The rotary joints are low-loss, low-noise cylindrical waveguide sections designed for the S-band application. The use of large cylindrical waveguide allows the rotary joint to be wideband.

The quarterwave plate is a waveguide device which retards the phase of half the incoming signal by 90 electrical degrees with respect to the other half, such that the incoming plane polarized signal is split into two spatially orthogonal components which travel at different velocities. Upon emergence, the two components will have the proper time and space phases to form a circularly polarized signal. If the retardation in phase corresponds to 180 electrical degrees (as by adding a second quarterwave plate), the circularly-polarized signal will again be linearly polarized. Any error in the alignment angle between the incoming signal and the upper quarterwave plate gives rise to orthogonal modes in the rotary joint which are not compensated by the reference quarterwave plate. These orthogonal modes develop an error signal at the error output port of the orthogonal mode transducer. The quarterwave plate is then rotated to compensate for the change of polarization of the incoming signal to null the error signal.

Notes:

1. The same combination of elements is also applicable to future experimental systems in the X-band region. In a more generalized version, it would be possible to use the apparatus to optimize reception or transmission of arbitrarily polarized elliptical waves simply by not restricting the second quarterwave plate to exactly ± 45° positions.
2. The polarimeter has been mounted on the 210-foot Cassegrainian spacecraft tracking antenna at Goldstone, California and was used to measure the Faraday rotation suffered by the 2292-MHz, S-band telemetry carrier of Pioneers when the signals interacted with the plasma and the magnetic field in the solar corona.
3. Requests for further information may be directed to:

   Technology Utilization Officer
   NASA Pasadena Office
   4800 Oak Grove Drive
   Pasadena, California 91103
   Reference: TSP 73-10134

Patent status:

NASA has decided not to apply for a patent.

Source: Gerald S. Levy, Dan A. Bathker, and Frank E. McCrea of Caltech/JPL under contract to NASA Pasadena Office
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